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# THE PHOTONICS DICTIONARY®

THE  
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**PURCHASING  
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The International Dictionary for  
Photonics: High-Technology  
Optics, Electro-Optics, Lasers,  
Fiber Optics and Imaging.

In This Book:  
Abbreviations and Symbols  
Definitions  
Illustrations

1986

EXHIBIT A

From the publishers of PHOTONICS SPECTRA® magazine



# THE PHOTONICS DICTIONARY®

**1986  
BOOK 3  
32ND  
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Edited by Robert S. Clark

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**Dichroic Filter.** A filter used to selectively transmit light according to its wavelength and not its plane of vibration.

**Dichroic Mirror.** A mirror used to selectively reflect light according to its wavelength and not its plane of vibration.

**Dichroic Polarizer.** A polarizer that consists of dichroic, polarizing material embedded in a plastic sheet, and that transmits light that is almost completely plane polarized with an intensity that is half that of the incident beam. The particles of the dichroic material are oriented so that the crystals or molecules are in the same direction.

**Dichroic Ratio.** The ratio between two given absorption coefficients.

**Dichroism.** 1. In reference to anisotropic materials, the selective absorption of light rays that vibrate in one particular plane relative to the crystalline axes. Those rays that vibrate in a plane at right angles thereto are not absorbed. 2. In reference to isotropic materials, the selective reflection and transmission of light as a function of wavelength, regardless of its plane of vibration. The color of these materials varies with the thickness of the examined material.

**Dichroscope.** A device used to investigate the dichroism of crystals.

**Dichroscopic Eyepiece.** An eyepiece used in a polariscope or polarizing microscope to give a comparison view of the same object under illumination by the two complementary rays of polarized light.

**Didymium Glass.** Glass tinted with mixed oxides of neodymium and praseodymium that, unlike most solid materials, have absorption bands that are very narrow and that have very sharp areas.

**Dielectric.** Characteristic of materials that are electrical insulators or in which an electric field can be sustained with a minimum dispersion of power. They exhibit nonlinear properties, such as anisotropy of conductivity or polarization, or saturation phenomena.

**Dielectric Anisotropy.** The dielectric coefficient in a liquid crystal is not, in general, the same in all directions with respect to the director. Dielectric anisotropy is the difference between the dielectric along the director and the dielectric perpendicular to the director.

**Dielectric Coated Gratings.** Shallow, fine-pitch diffraction gratings having a precise dielectric overcoating that experimentally have absorbed wavelength-specific incident light that is polarized in the P-plane.

**Dielectric Constant.** A number that indicates the magnitude of the shift in a solid of positive and negative charges in opposite directions when a voltage is applied across the solid.

**Dielectric Crystal.** A crystal that is characterized by its relatively poor electrical conductance.

**Dielectric Cylindrical Waveguide.** Waveguide made up of a dielectric material, such as plastic or mica, in a cylindrical form, through which the waves travel.

**Dielectric Lens.** A lens made up of a dielectric material that is capable of influencing radio waves much in the same way an optical lens influences light.

**Difference Threshold.** The minimum of change in stimulation needed to effect an awareness of change in sensation that is statistically determined.

**Differential Interferometer.** A device that produces an interferogram that can be directly related to the temperature gradient and thereby provides a direct measure of the convective heat transfer coefficients.

**Differential Mode Attenuation.** The variation in attenuation among the propagating modes of an optical fiber.

**Differential Quantum Efficiency.** The slope of the curve when output is plotted against input for quantum efficiency in a device.

**Differential Spectrophotometry.** The measurement of the spectrum bands formed by a spectroscopic sample, based on the differences between the sample and the reference cell it is placed in.

**Diffraction.** As a wavefront of light passes by an opaque edge or through an opening, secondary weaker wavefronts are generated apparently originating at that edge. These secondary wavefronts will interfere with the primary wavefront as well as with each other to form various diffraction patterns.

**Diffraction Angle.** The angle that lies between the direction of an incident light beam and any resulting diffracted beam.

**Diffraction Efficiency.** The ratio of incident flux to usable diffracted flux.

**Diffraction Fanning.** The formation of a fan of light or energy rays in a beam as the beam passes through an extremely narrow aperture.

**Diffraction Gratings.** A glass substrate carrying a layer of deposited aluminum that has been pressure-ruled with a large number of fine equidistant grooves, using a diamond edge as a tool. Light falling on such a grating is dispersed into a series of spectra on both sides of the incident beam, the angular dispersion being inversely proportional to the line spacing. By proper shaping of the diamond edge, however, the grooves can be formed in such a way as to concentrate most of the energy into a single spectral order; such a grating is said to be "blazed." Cast replica gratings can be made in plastic or another substrate, the replica being used either as a transmitting grating or by aluminizing it, as a reflecting grating. Plane gratings require external optics to focus the spectral lines, but a grating ruled on a concave surface has self-focusing properties.

**Diffraction Grating Spectrograph.** A spectrograph that uses a diffraction grating as its dispersive element, in place of a prism, and yields greater resolving power, more dispersion and a linear spectrum.

**Diffraction Image.** See Geometrical Image.

**Diffraction Limited.** The property of an optical system whereby only the effects of diffraction determine the quality of the image produced by the system.

**Diffraction-Limited Lens.** A lens with aberrations corrected to the point that residual wavefront errors are substantially less than  $\frac{1}{4}$  the wavelength of the energy being acted upon.

**Diffraction Pattern.** The interference pattern formed by light waves diffracted at the edges of an object as seen on a screen placed in their path.

**Diffraction Rings.** 1. The ring patterns of light that seem to encircle particles in the field of a microscope. 2. See Newton's Rings.

**Diffraction Scattering.** Elastic scattering due to the fact that inelastic processes eliminate particles from the beam.

**Diffraction Spectrum.** In spectroscopy, the parallel bands that vary in lightness and darkness or color, and that are formed when light is diffracted by a sample.

**Diffraction Velocimeter.** See Laser Velocimeter.

**Diffractometer.** A measurement device used to study the structure of matter using the diffraction of electromagnetic radiation.

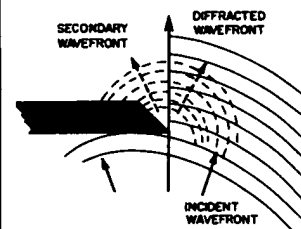
**Diffractometry.** The study of the diffraction of beams of a wave by matter to ascertain the structure of the matter.

**Diffraction Microscopy.** See Zero-Order Filtering.

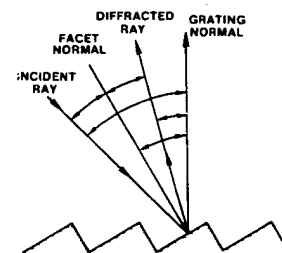
**Diffuse-Cutting Filter.** A color filter that is designed to gradually increase or decrease its absorption with wavelength.

**Diffuse Density.** The logarithm of the reciprocal of diffuse transmittance. Diffuse density results when a sample is diffusely illuminated.

**Diffuse Illumination.** Light emitted by one or more sources and characterized by a high degree of scatter.



Diffraction.



Diffraction Grating.

focal plane of a lens so that each object gives rise to a parallel beam of light incident on the plate. A collimated reference beam strikes the plate at an angle relative to the object beam.

**Fourier Transform Spectrometer.** An instrument using a Michelson interferometer, a beam-splitter, two plane mirrors and a detector to give Fourier analysis of the detector signal to provide the desired spectrum.

**Four-Level Laser.** A solid-state laser consisting of active atoms or ions of a transition metal, rare-earth metal or actinide, imbedded in a crystal or glass material, often garnet. Excitation and transfer to different energy levels are similar to those of the three-level laser. However, there is a fourth, usually unoccupied level above ground level where the laser light terminates before spontaneous decay returns it to ground level.

**Fovea.** The central portion of the retina that has the greatest sensitivity to form and color.

**Foveal Vision.** See Photopic Vision.

**Fractional Fringes.** Measurement technique that uses a set of fractional fringes having a length interferometrically determined with two or more wavelengths. Only one discrete set of equally spaced lengths will satisfy that set of measured exact fractions.

**Frame.** 1. To center an image or place it in any part of the TV screen desired. Also applies to stills. 2. A single image of the connected multiple images on motion-picture film. 3. The size of the copy produced by a facsimile system.

**Frame Camera.** A high-speed cine camera that produces discrete frames of a continuous event as opposed to the flow photographic record of a streak camera.

**Frame Frequency.** The amount of times per second that the screen of a television is completely scanned. In the United States, 30 per second is the standard frame frequency.

**Framer.** A device that permits the adjustment of facsimile transmitters and recorders so that their scanning lines stop and start at the same place in relation to the subject copy.

**Frames per Second.** The number of separate images exposed by a cine camera in a second, or the number illuminated by a cine projector in a second. By varying the number of images recorded per second, films that show fast or slow motion as well as normal motion when projected can be created.

**Franck-Condon Principle.** The principle stating that electronic energy transitions occur at such speed that the nuclei of the atoms in the molecular system remain stable during the transfers.

**Franz-Keldysh Effect.** Observed lengthening in wavelengths of the optical absorption edge of a semiconductor with the application of an electric field.

**Fraunhofer Diffraction Pattern.** Synonym for Far-Field Diffraction Pattern, which see. (EIA)

**Fraunhofer Hologram.** A far-field pattern holographically reproduced image that is categorically considered with three-dimensional lensless photographs.

**Fraunhofer Lines.** The dark absorption lines observed in the spectrum of the photosphere of the sun. There are thousands of these lines, the most prominent of which were observed and named by Fraunhofer early in the 19th century.

**Frdholm Integral.** The mathematical formula that proves that any linear operator for which the impulse is known can be wholly characterized according to its impulse response.

**Free-Abrasive Machining.** The process whereby a rotating wheel carries grains of an abrasive, suspended in a vehicle, across the surface of the optical glass to be ground. The workpieces are forced downward by pneumatic cylinders driving pressure plates that fit within the retaining ring. The machine for polishing uses the same method with

a solid aluminum plate and pad cemented to the plate in place of the hardened grinding process.

**Free Aperture.** See Clear Aperture.

**Free-Carrier Absorption.** The phenomenon whereby an electron within a band absorbs radiation by transferring from a low-energy level to an empty high-energy level.

**Free-Carrier Photoconductivity.** Photoconductivity that may be extended as far as the microwave region, due to the absorption of photons by electrons.

**Free Radicals.** Short-lived molecular or atomic particles, with an unpaired electron, that play an important part in many photochemical reactions.

**Frequency.** With reference to electromagnetic radiation, the number of crests of waves that pass a fixed point in a given unit of time, in light or other wave motion.

**Frequency-Division Multiplex (FDM).** A system that allows the transmission of more than one signal over a common path, by assigning each signal a different frequency band. Also known as Wavelength-Division Multiplex (WDM), the term more commonly used in fiber optic communications.

**Frequency Doubling.** A nonlinear optical process in which the frequency of an optical beam is doubled coherently.

**Frequency Summing.** A technique used in holography that involves the mixing of lasers of different wavelengths to produce a beam of shorter wavelength.

**Fresnel.** A unit of frequency equivalent to  $10^{12}$  cycles per second. (Pronounced with silent s.)

**Fresnel Diffraction.** 1. Also known as Near Field Diffraction. The field of radiation sent through an aperture in an absorbing screen at large distances as compared to the wavelength and the dimensions of the aperture, but small enough to necessitate consideration of the effect of the phase differences between secondary wavelets. 2. The effect of diffraction obtained when the source of radiation and/or the observing screen are at a finite distance from the diffraction aperture or obstacle.

**Fresnel Fringe.** A single band in a group of light and dark bands that can be viewed in the periphery of Fresnel diffraction shadow.

**Fresnel Hologram.** A hologram formed with an object located close to the recording medium.

**Fresnel Lens.** A lens resembling a plano-convex or plano-concave lens that is cut into narrow rings and flattened out. If the steps are narrow, the surface of each step is generally made conical and not spherical. Fresnel lenses can be large glass structures as in lighthouses, floodlights, or traffic signals, or a thin molded plastic plate with fine steps, often used for field lenses.

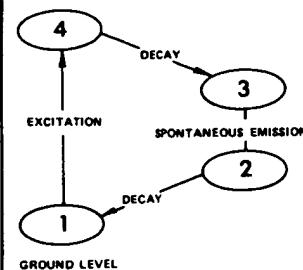
**Fresnel Loss.** See Surface Reflection.

**Fresnel Mirrors.** Two plane mirrors that are not wholly located in the same plane. When light from a point source or slit reflects from the two mirrors, interference bands are revealed in the region where the light reflected from one mirror overlaps the light reflected from the other.

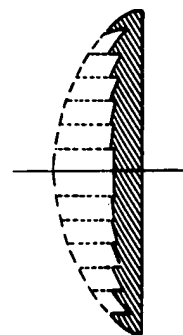
**Fresnel Number.** In a lens, the square of the radius of its aperture divided by the product of the focal length and the wavelength. It measures the importance of diffraction in the image formed by the lens. A small Fresnel number indicates greater effects of diffraction. The Fresnel number has been used in lasers with the distance to the following aperture in a resonator replacing the focal length, and it has proved efficient in determining the diffraction loss.

**Fresnel Reflection.** The reflection of a portion of light resulting when light is incident upon the surface between materials that have different refractive indices. This Fresnel reflection depends upon the index difference and the angle of incidence. Such reflection occurs at the air-glass interfaces at entrance and exit ends of an optical waveguide.

## FRESNEL REFLECTION



**Four-Level Laser.**  
THE ENERGY-LEVELS IN THE FOUR-LEVEL LASER.



**The Fresnel Lens.**

solar irradiance, atmospheric transmittance and camera spectral responsivity, and the unknown spectral reflectance.

**Reflectance Factor.** Ratio of the directionally reflected flux to that reflected in the same direction by a perfect reflecting diffuser identically irradiated or illuminated.

**Reflectance Spectrophotometer.** An instrument that spectrally analyzes the flux reflected from a material. The reflected flux may be total, diffuse, or specular. Often, the instrument measures the reflectance factor instead of the reflectance.

**Reflected Light Meter.** An exposure meter designed to measure the light emitted by the object.

**Reflected Ray.** The light ray leaving a reflecting surface, indicating the path of light after reflection.

**Reflected Ultraviolet Photography.** A photographic method used to obtain an image of a subject by means of its reflectance of incident ultraviolet radiation. An ultraviolet source is used to irradiate the subject, while the reflected image is recorded with a camera equipped with a filter that will only transmit ultraviolet radiation.

**Reflecting Galvanometer.** A galvanometer having a small mirror that is mounted on a moving element and that reflects a light beam onto a scale.

**Reflecting Microscope.** A microscope that uses a reflecting objective; often used with ultraviolet or infrared radiation.

**Reflecting Objective.** An image-forming system that uses mirrors rather than lenses. Such objectives are frequently used for astronomical telescopes and in ultraviolet microscopes.

**Reflecting Prism.** A prism having several plane polished surfaces, some to transmit light, some to reflect light, and some to serve both functions in succession. It acts generally as a group of plane mirrors held in a fixed relationship.

**Reflecting Spectrograph.** A solar spectrograph that uses long focus concave mirrors as its collimator and camera element.

**Reflecting Telescope.** A telescope that uses a reflecting objective to focus an image of a distant object at a focal point.

**Reflection.** Return of radiation by a surface, with out change in wavelength. The reflection may be specular, from a smooth surface; diffuse, from a rough surface or from within the specimen; or mixed, a combination of the two.

**Reflection Coefficient.** Parametric measurement for elliptical fiber and cable expressed as a ratio of the two-directional flow of power through the cable at any chosen point.

**Reflection Echelon.** An echelon in which the dihedral angle between the faces of the groove is 90°.

**Reflection Factor.** See Reflectance Factor.

**Reflection Grating.** A diffraction grating ruled on a reflecting surface that reflects light and forms spectra.

**Reflection Hologram.** A hologram that is illuminated by a source from the viewer's side.

**Reflection Image.** An image produced by a reflecting surface. An unwanted reflection image is commonly termed a Ghost Image.

**Reflection Reduction Coating.** The thin, transparent film made up of specific substances applied to glass-air surfaces for the purpose of decreasing the amount of reflected light.

**Reflection X-Ray Microscopy.** A method of magnifying images by means of x-rays. In this method the radiation is reflected at glancing incidence from polished concave mirrors or from the curved surfaces of single crystals by Bragg reflection. The problem of aberration corrections still restricts the resolution obtainable.

**Reflective Coating.** Thin film coating, single or multilayer, that is applied to a substrate to increase its reflectance over a specified range of wavelengths. Metal film, transparent or opaque, is the oldest form of reflective coating.

**Reflective Heat Mirror.** See Diathermic Mirror.

**Reflectivity.** The ratio of the intensity of the total radiation reflected from a surface to the total incident on that surface.

**Reflectometer.** An instrument for measuring reflectance.

**Reflector.** A type of conducting surface or material used to reflect radiant energy.

**Reflector Lamp.** A lamp used in projection that is made with a reflector built into the bulb, normally by coating a portion of its interior with a reflective material, to insure the reflector's optimum position in relation to the light source.

**Refracted Near-Field Scattering Method.** See Refracted Ray Method.

**Refracted Ray.** In an optical waveguide, a ray that is refracted from the core into the cladding. (EIA)

**Refracted Ray Method.** The technique for measuring the index profile of an optical fiber by scanning the entrance face with the vertex of a high numerical aperture cone and measuring the change in power of refracted (unguided) rays. (EIA)

**Refracted Wave.** A wave of radiation that has undergone refraction.

**Refracting Prism.** A prism that is often used as a dispersing element in spectrographs and monochromators.

**Refracting Sphere.** A transparent sphere that has an index of refraction that is different from that of the medium surrounding it; used in optics to demonstrate refraction and astigmatic image formation.

**Refraction.** The bending of oblique incident rays as they pass from a medium having one refractive index into a medium with a different refractive index.

**Refractive Index.** See Index of Refraction.

**Refractive Index Liquids.** A closely-spaced series of well-known chemicals having a refractive index lying between 1.33 for water and 1.95 for a solution of phosphorus in carbon disulphide. They are used to identify powdered minerals, since a transparent powder disappears from view when immersed in a liquid of the same refractive index.

**Refractive Index Profile.** The description of the refractive index along a fiber diameter. (EIA)

**Refractometer.** An instrument for measuring refractive indices of solids, liquids or gases. Several types of refractometers have been developed, the most common types being the Abbé, Pulfrich and Rayleigh. To measure a solid on a refractometer, the refractive index of the prism in the instrument must have a refractive index higher than that of the specimen, and a contact liquid with an intermediate refractive index must be available.

**Refractometry.** The method used to determine the refractive index of a given substance.

**Regenerative Repeater.** A repeater that is designed for digital transmission. Also called a regenerator. (EIA)

**Regular Reflection.** See Specular Reflection.

**Regular Transmittance.** The part of incident flux that is transmitted with no scattering.

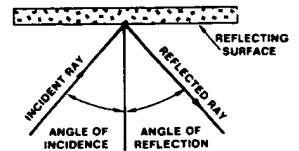
**Relative Aperture.** The ratio of the diameter of the entrance pupil in an optical system to the equivalent focal length of that system. The relative aperture is denoted as a fraction in which  $f$ , the equivalent focal length, is the numerator, and it is symbolized by  $f/$  followed by a numerical value. The ratio  $f/2$  indicates that the diameter of the entrance pupil is equal to  $1/2$  the equivalent focal length.

**Relative Detector Response ( $D(\lambda)$ ).** A plot showing how the response (ability to detect a signal) varies with wavelength.

**Relative Equilibrium.** The steady state of temperature exhibited by a material that has absorbed and emitted radiation equally.

**Relative Index.** The ratio of the velocities of light in two adjacent media neither of which is air.

**Relative Refractive Index.** The quantity equal to the refractive index of one medium divided by that of a second medium.



Reflection.